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Observations of some Pleistocene outcrops in Ceylon

by

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The present paper is based upon a brief field observation in Ceylon made by the writer from March 15 through March 29, 1968, after his two-month geological survey in India. The survey was part of the lowland paddy soil study program for South and Southeast Asia, directed by Professor K. Kawaguchi, Kyoto University, Japan.

I Physiographical setting

Three distinct peneplains, i. e., the “highest, middle and lowest peneplains” and a “coastal plain” have been reported in Ceylon as shown in Fig. 1.²⁾ In this paper, fifteen representative Quaternary outcrops on the “lowest peneplain” and “coastal plain” are described and subdivision of the Quaternary formation is attempted.

With regard to the basement rock, Ceylon may be divided roughly into three parts, i. e., the Jaffna limestone region which is composed limestone, the Vijayan series region mainly made up of such acidic rocks as granite and gneiss, and the Highland series region of more complicated combination with basic rocks.²⁾ The Quaternary deposits developed on the former two regions are exclusively composed of arkose materials which are derived from the Vijayan series, whereas the deposits in the Highland series region is rich in mafic mineral components. The characteristic weathering features which develop on Quaternary geological bodies are used as markers of stratigraphical horizon in this paper. In this connection, only the more homogeneous geological bodies on the Jaffna and Vijayan series regions have been chosen for description as well as analysis, the obvious reason being that different material provides a different weathering product and weathering degree, and consequently, stratigraphical correlation on the basis of weathering feature is sound only when the material is of the same nature. In the Highland series region more heavily weathered features may occur than those seen in the Jaffna and Vijayan series regions.

The areas observed are shown by cross section lines in Fig. 2 as well.

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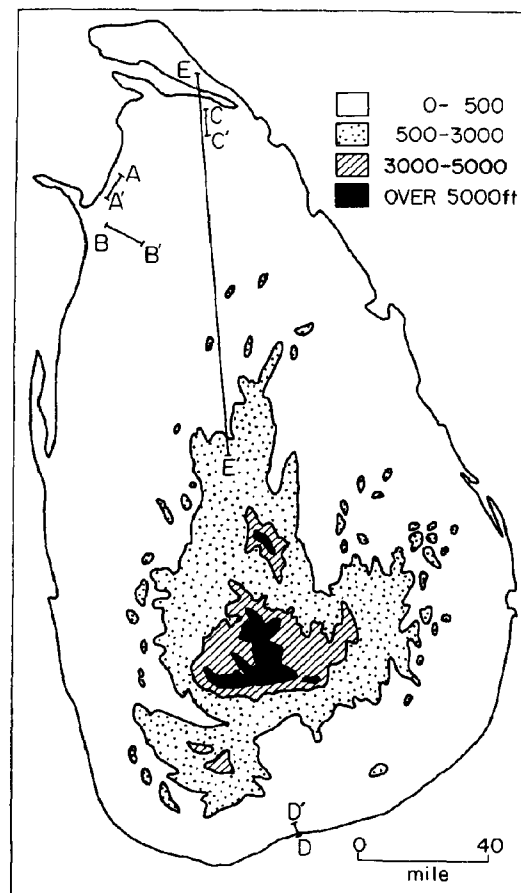
Plain	Highest peneplain	Middle peneplain	Lowest pene. & coastal plain
Elevation (ft)	4,000-8,000	500-2,500	0-300
Average elevation (ft)	5,000-6,000	1,500	<100
			

Fig. 1 Diagrammatic section across Ceylon showing the three peneplains and the coastal plain (cited from P. G. Cooray, 1967)



- A-A': Mannar area (see Fig. 3)
 B-B': Mannar area (see Fig. 4)
 C-C': Kilinochchi area (see Fig. 5)
 D-D': Ambalantota area (See Figs. 6 and 7)
 E-E': Lowest and middle peneplain (see Fig. 8)

Fig. 2 Index map for the cross sections with the relief (cited from P. G. Cooray, 1967)

II Results of the observation

(Mannar area)

This area includes the lower part of the so called "lowest peneplain" and the "coastal plain". The geological mode is illustrated in Figs. 3 and 4.

Loc. 1: Milestone $12 + \frac{1}{2}$ on the road from Mannar to Pooneryn; very flat barren land; ca 2.5 m above sea level.

0.0-0.1 m: Medium to coarse sand with many ilmenite and pink colored quartz grains; fresh. (0)

0.1-0.5 m: Olive brown (2.5 Y 4/6, wet) heavy clay; common gray to dark gray (N 6-N4) cloudy mottlings; very strong medium to fine, angular blocky; many calcareous nests and few calcareous concretions (ϕ 0.5-2.0 cm); no ferruginous and manganiferous concretions. (I)

Loc. 2: 1/4 mile ahead of milestone 18 on the road from Mannar to Pooneryn; very flat grass land with few patches of paddy field; gilgai micro-relief; ca 4 m above sea level.

0.0-1.0 m: Dark grayish brown (moist) clay; few sand grains; very few manganiferous concentrations. (I)

1.0-3.0 m: Yellowish brown (10 YR 4/3, moist) to dark brown (10 YR 5/4, moist) clay with common sand grains and granules; common bluish gray cloudy mottlings; few iron-manganese concretions (ϕ 0.2-0.5 cm); few calcareous concretions (ϕ 1.0-1.5 cm); very few ferruginous concretions (ϕ 0.3-0.8 cm). (II)

Loc. 3: Milestone 130 on the road from Kandy to Mannar; flat to slightly undulating bush land; ca 13 m above sea level.

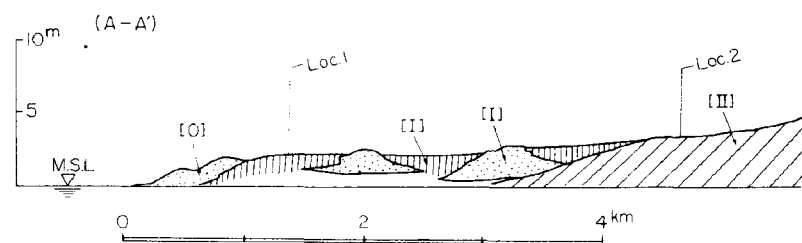


Fig. 3 Schematic cross section of the coastal plain in Mannar area

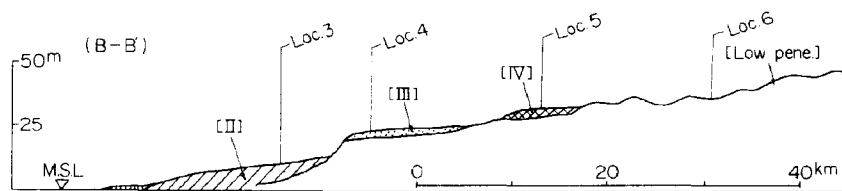


Fig. 4 Schematic E-W cross section showing the relationship between the coastal plain and the lowest peneplain in Mannar area

0.0-0.5 m: Very dark gray (10 YR 3/1, moist) heavy clay; common dark yellowish brown (10 YR 4/6, moist) tubular mottlings; common colorless and pink colored quartz grains (ϕ 0.1-0.2 cm); few calcareous concretions (ϕ 0.5-1.5 cm) and very few iron-manganese concretions (ϕ 0.2-0.6 cm). (II)

0.5-1.0 m: Black (10 YR 2/1, moist) heavy clay; prominent slickensides with sand fillings; many calcareous concretions (ϕ 0.5-2.0 cm); very few iron-manganese concretions (ϕ 0.2-0.8 cm). (II)

Loc. 4: Milestone 127 on the road from Kandy to Mannar; undulating thorny bush land; ca 20 m above sea level.

0.0-0.5 m: Dark gray (10 YR 4/1, moist) clay with common quartz grains and many grass roots. (0)

0.5-3.0 m: Light brownish gray to light yellowish brown clayey coarse sand; common pebble; many iron-manganese concretions (ϕ 0.2-0.5 cm) and many calcareous concretions (ϕ 1-2 cm); few lateritic fragments (up to 3 cm long) (III)

Loc. 5: 1.5 mile N of the milestone 124 on the road from Kandy to Mannar; undulating forest land; ca 30 m above sea level.

0.0-1.0 m: Honey-comb structured lateritic layer with many rounded to angular quartz grains (ϕ 0.2-0.5 cm). (IV)

1.0-2.0 m: Coarse sand with gravels hardly cemented by lateritic material. Gravels are rounded to subangular and quartzitic. (IV)

2.0-3.0 m: Very heavily weathered granitic rock; accumulation of kaolinic material. (IV)

Loc. 6: 1/4 mile E of the milestone 122 on the road from Kandy to Mannar; undulating to rolling forest land; ca 35 m above sea level.

0.0 m+: Granitic rocks of Vijayan series without lateritic cover. (V)

(Kilinochchi area)

This area covers the "coastal plain" and the lower part of the "lowest peneplain". The geological mode is shown as in Figs. 5 and 8.

Loc. 7: Paranthan Paddy Station; flat paddy field; ca 15 m above sea level.

0.0-0.25 m: Dark gray (7.5 Y 4.5/1, wet) to gray (5 Y 5/1, moist) sandy loam; common to many reddish yellow (7.5 YR 6/6, moist) mottlings. (I)

0.25-0.8 m: Gray (5 Y 6/1, moist) to light gray (5 Y 7/1, moist to wet) sandy loam;

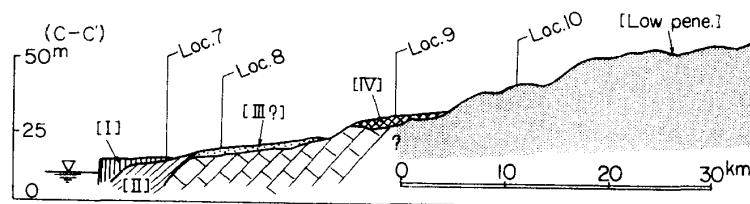


Fig. 5 Schematic N-S cross section showing the coastal plain and the lowest peneplain in Kilinochchi area

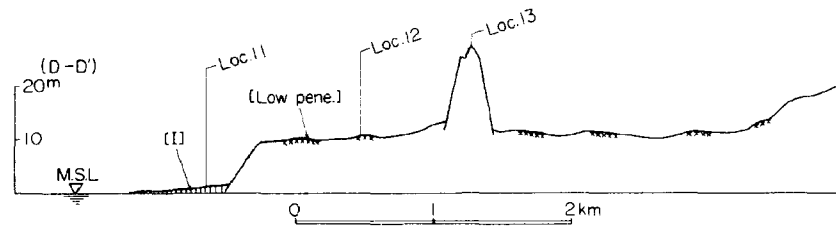


Fig. 6 Schematic N-S cross section showing the coastal plain and the lowest peneplain in Ambalantota area

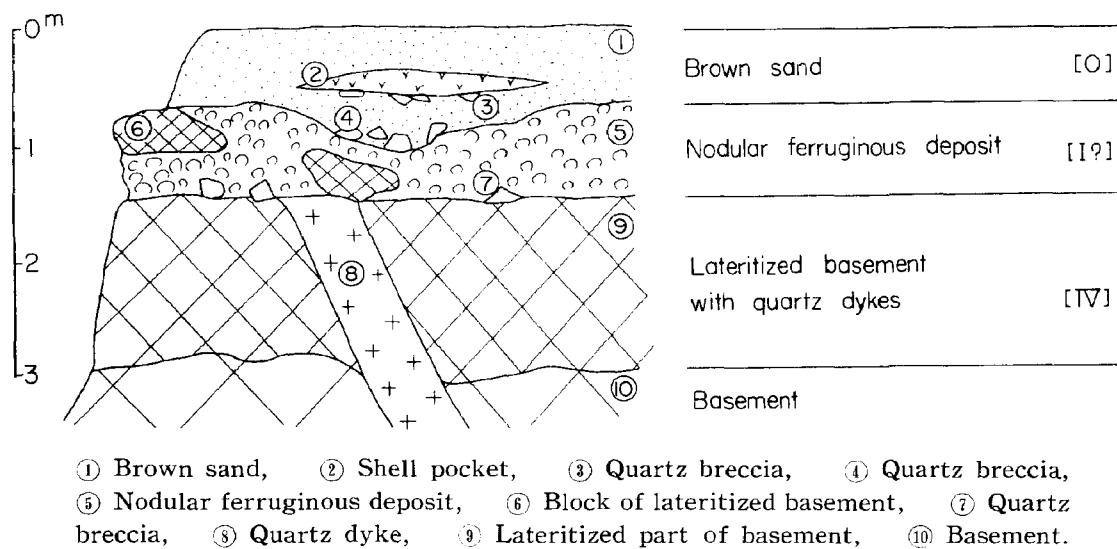


Fig. 7 Sketch of outcrop at Loc. 12, in Ambalantota area

many reddish yellow to yellowish red mottlings; common manganiferous concretions. (II)

(after Kawaguchi and Kyuma's unpublished data of 1965)

Loc. 8: Milestone 162 on the road from Kandy to Jaffna; flat to slightly undulating grass land; ca 20 m above sea level.

0.0-1.3 m: Gray (5 Y 6/1, moist) sandy clay; common brownish yellow (10 YR 6/8) cloudy mottlings; common quartz grains (ϕ 0.3-0.5cm); few botryoidal iron-manganese concretions. (III ?)

1.3 m+: Miocene limestone.

Loc. 9: Milestone 155 on the road from Kandy to Jaffna; undulating open forest land; ca 30 m above sea level.

0.0-0.3 m: White (10YR 8/2, moist) clayey sand with many angular to rounded quartz grains (ϕ 0.2-0.4 cm). (0)

0.3-0.7 m: Yellow (10 YR 7/6, moist) sandy clay; common red (2.5 YR 5/8) cloudy mottlings; many quartz grains (ϕ 0.2-0.5 cm). (0)

0.7-1.5 m: Honey-comb structured hard lateritic material; common angular to rounded

- pebbles (ϕ up to 2 cm) and common granules. (IV)
- 1.5 m + : Very heavily weathered, garnet bearing gneiss; accumulation of kaolinic material. (IV)
- Loc. 10:** Milestone 149 on the road from Kandy to Jaffna; undulating to rolling forest land; ca 40 m above sea level.
- 0.0–2.0 m: Medium to coarse sand with many angular quartz grains (ϕ 0.2–0.7 cm); moderately cemented with strong brown (7.5 YR 4/8, moist) clayey materials; no mottlings. (0)
- 2.0 m + : Fresh garnet bearing gneiss. (Low pene.)
- (Ambalantota area)

This area comprises the lower part of the “lowest peneplain”. The cross section is shown in Fig. 6.

- Loc. 11:** ca 3/4 mile S of the milestone 138 on the road from Colombo to Batticaloa; very flat and very gently seawards sloped bush land; ca 2.5 m above sea level.
- 0.0–0.3 m: Dark yellowish brown (10 YR 4/6, moist) sandy silt; common quartz grains (ϕ 0.1–0.2 cm); few calcareous nests (0.5 cm long). (I)
- 0.3–1.0 m: Light olive brown (2.5 Y 5/3, moist) clay with few quartz grains; common calcareous nests (up to 1.0 cm long). (I)

Numerous shell fragments, most probably habitation refuse, are scattered on the ground surface.

- Loc. 12:** Milestone 138 on the road from Colombo to Batticaloa; undulating bush land; ca 12 m above sea level. (see Fig. 7)
- 0.0–0.7 m: Strong brown (7.5 YR 4/6, moist) clayey sand; loosely indurated; intercalating shell pockets.
- 0.7–1.5 m: Aggregate of nodular iron stone with red (2.5 YR 4/8, moist) clayey matrix; common angular quartz grains (ϕ 0.2–0.4 cm); few extraneous lateritic blocks

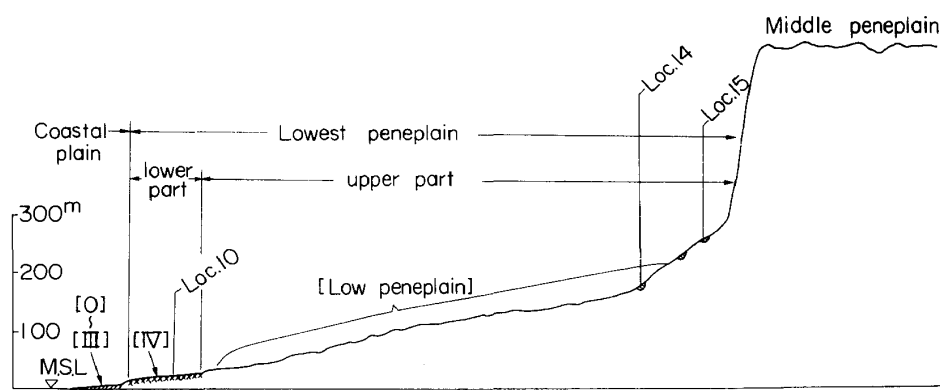


Fig. 8 Schematic cross section showing relationship of the upper part of the lowest peneplain to the other plains

- (ϕ up to 50 cm); few angular to subangular quartz breccia (ϕ up to 10 cm).
 1.5-3.0 m: Very heavily weathered gneiss; reticulate mottling in various color ranging from red to blue; partly changing to a honey-comb structured hard laterite. Quartz dyke is comparatively fresh.
 3.0 m+: Weathered gneiss.
Loc. 13: North of milestone 138 on the road from Colombo to Batticaloa; monadnock composed of fresh gneiss.
Loc. 14: Milestone 36 on the road from Kandy to Jaffna; undulating to rolling bush land; many lateritic blocks (up to 1 m long) on peneplain like ground surface covered with reddish colored soils. (see Fig. 8)
Loc. 15: Milestone 30 on the road from Kandy to Jaffna; undulating to rolling bush land; many lateritic blocks on peneplain like surface covered with reddish colored soils. (see Fig. 8)

III Stratigraphy and correlation

1. Stratigraphy

Based on the cross sections shown in the previous chapter, a provisional stratigraphy is proposed as shown in Table 1. The character of each formation is summarized below.

(Formation 0)

The present beach sand (Fig. 3), lagoonal and estuarine deposits etc. belong to this formation and the brown sand with shell pockets at Loc. 12 may be treated as a corresponding terrestrial bed of this formation. Deposition is still going on and the

Table 1 Provisional Quaternary stratigraphy in the northern part of Ceylon

stratigraphical stage	formation	surface height (m)	weathering feature
	0	0-1	No weathering product
Post glacial high sea level	I	2-3	Common calcareous nests and very few iron and manganiferous concretions (ϕ 1 m/m)
Last interglacial	II	6 \pm	Common calcareous concretions and few iron and manganiferous concretions (ϕ 3-5 m/m)
	III	10-30	Common calcareous concretions and common lateritic fragments (long dimension: up to 3 cm)
Penultimate interglacial	IV	30 \pm	Thin lateritic capping
	L. P	40-200	Red colored clayey sand with mica flakes, accidentally lateritic blocks

constituent in this formation is usually very fresh without any distinct weathering product.

(Formation I)

The raised beach sands and their associate deposits as seen at Locs. 1 and 11 belong to this formation. Nodular ferruginous deposits at Loc. 12 may be a terrestrial equivalent of this formation.

The Formation I that develops along coastal area has a very flat depositional surface 2 to 3 m above sea level. The olive brown clay at Loc. 1 has the characteristic appearance of marine origin. These facts seem to imply that the Formation I was closely connected with the presumed high sea level of the latest Quaternary age.

Calcareous nests and concretions are common, yellowish and brownish mottlings due to the segregation of ferruginous and manganiferous materials are not rare. But the typical concretions of iron manganese oxide have not yet evolved.

(Formation II)

The yellowish brown to dark brown clay at Loc. 2 and the very dark gray and black clays at Loc. 3 belong to this formation. The depositional surface of this formation, 4 to 10 m above sea level, stretches in an extensive, slightly undulating gentle seaward inclination. This topographical feature suggests that a marine environment predominated in the area during the deposition of the formation.

The pisolitic iron-manganese concretions 0.3 to 0.8 cm across are characteristic of this formation, and are quite similar to the concretions which occur in the upper Pleistocene deposits in Thailand¹⁾ and Cambodia⁵⁾. Calcareous concretions which are more highly crystallized than those found in Formation I commonly occur.

(Formation III)

The pebble bearing coarse sand at Loc. 4 and the sandy clay with granules at Loc. 8 belong to this formation. Formation III is composed in most cases of a very thin sandy overlay which develops on an undulating strip of land 10 to 30 m above sea level. This feature indicates that the formation is more erosional than depositional.

Lateritic concretions up to 5 cm long are commonly contained in this formation. It is not yet determined, however, whether these concretions are *in situ* products or derived from Formation IV which stretches just along the inland side of Formation III.

(Formation IV)

The gravelly sand with a lateritic cap at Loc. 5 belongs to this formation and the honey-comb structured hard laterite at Loc. 9 and the lateritized part of basement rock seen at Loc. 12 are considered to be the simultaneous weathering products of this formation.

The gravelly sand with a lateritic cap at Loc. 5 most probably corresponds to the "red-yellow latosols" (unit 5 of C. R. Panabokke's General Soil Map, 1967)⁴⁾ judging from its general field occurrence. Panabokke stated that the latosols occur on land

which would correspond to an ancient coastal shelf or terrace⁴⁾. Actually, these latosols shown on the soil map clearly demonstrate the characteristic pattern of distribution which reminds Quaternary geologists of the beautiful arrangement of coastal terraces. In this context, the writer considers that Formation IV represented by gravelly sand is a kind of coastal terrace formation. The average height of this terrace is around 30 m.

The gravelly sand almost exclusively has a lateritized top 0.5 to 1.0 m thick and this feature can be traced laterally to gneiss areas in which no terrace gravel develops. Lateritic materials at a surface height of about 30 m, e. g. seen at Locs. 9 and 12 can equally be determined as Formation IV in this way.

(Low peneplain)

Between an elevation of 40 to 100 m, an undulating to rolling surface develops very extensively, on which a very thin overlay of coarse sand with a red clayey matrix are commonly found (see Fig. 8). This surface is termed Low peneplain in this paper.

The coarse sandy overlay is obviously of eluvium and the lateritic layer as found on Formation IV does not appear here. By contrast, abundant mica flakes are found scattered. This implies that erosion is actively in progress and fresh primary minerals are continuously being supplied from the underlying hard rock.

Small patches of lateritic development are, however, locally observed on the surface of this Low peneplain. For example, at Locs. 14 and 15, blocks of honey-comb structured hard laterite are found lying on a rolling ground surface, as shown in Fig. 8. This evidence seems to support Cooray's idea that the surface was once covered with an extensive lateritic layer which has mostly been washed away by later erosion.²⁾ This problem, however, can not be definitely resolved at present because the lateritic blocks occur only in the strips of basic rocks of the Highland series region, in which quite a different genetic mechanism for lateritization may exist.

In any case, the higher part of the so-called lowest peneplain is free from lateritic layer in general and can be said to be a more active and young erosional area.

The general characteristics mentioned above are mainly based on the evidence found in northern Ceylon. More or less disparate features may be observed in the rest of Ceylon, especially in regard to the height of each depositional or erosional surface. Attention should be paid to the effect of structural movement when discussing geological sequences of more extensive areas.

2. Correlation

A chart proposing tentative correlation appears in Table 2. Correlation with Paterson's stratigraphy³⁾ is made on the basis of the height of terrace surfaces and weathering feature, of which the writer had also a chance to make a short survey in Madras. Correlation with the deposits in the Narbada Valley³⁾ is made mainly

Table 2 Tentative correlation chart of the Quaternary geological bodies in Ceylon, India and Thailand

Ceylon	Narbada Valley (India)	Madras (India)	Thailand
Formation 0	New alluvium & regur	T ₃ & younger	Flood plain
Formation I			Formation I
Formation II	Upper Narbada group	T ₂	Formation II
Formation III		T ₁ ?	
Formation IV	Lower Narbada group	T _D	Formation III
Low peneplain*	Laterite (?)		Peneplain**

* Most lateritic cover has been eroded away by later erosions.

** Comparatively extensive lateritic distributions are still recognized on the surface.

through Paterson's correlation between the Narbada Valley and Madras. The characteristic weathering products, i. e. pisolitic concretions and a lateritic layer, are used as keys when making a comparison of the geological bodies of Ceylon and Thailand.¹⁾

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